UV Curable Powder Coatings for Aerospace Applications
ESTCP Project WP-0801

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Abstract

Temperature sensitive substrates such as aluminum and magnesium are used in the manufacture and sustainment of weapon systems and ground support equipment. This project will demonstrate, validate and successfully implement a VOC/HAP-free, UV-cure powder coating on DoD depot production hardware to replace solvent-borne organic coatings. The project will utilize both existing and new UV-curable powders in a side-by-side demonstration with the current existing wet paint system. The use of state-of-the-art-robotics will also be demonstrated.

Outline

- **Powder Coating Overview**
- **UV-Curable Powder Coatings Overview**
- **Robotics as an aid to Curing**
- **ESTCP Project WP-0801**

Powder Coating Overview

- **Previous ways of thinking about powder:**

  - **Coating cure temperatures – typically above 428°F**

  - **Prohibitive for use on tempered metals (Al, Mg, Ti)**

  - **Prohibitive to use on composites**

  - **Powder coatings were designed as barrier protection**

Today these are no longer limitations!

Powder Coating Overview

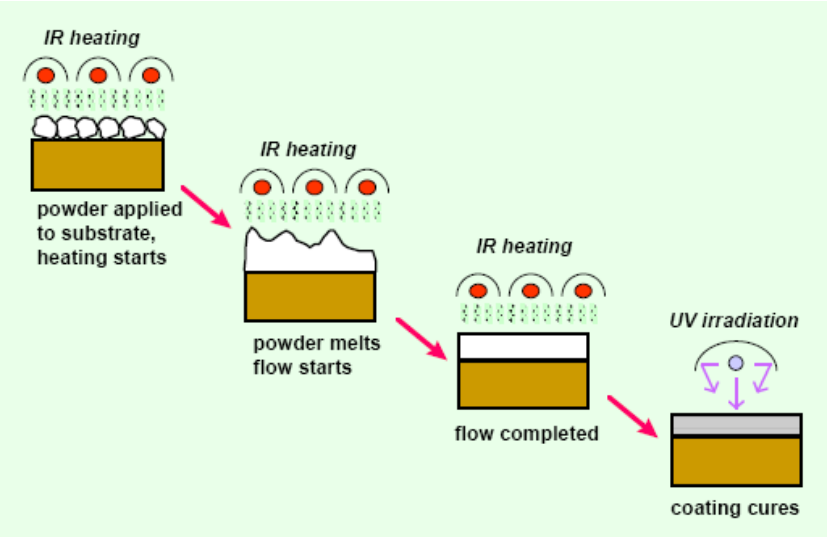
- **Modern powder coatings are:**
  - **Lower temperature cures (~ 250°F or less)**
  - **UV or EB cure added**
  - **Inhibitor packages available**

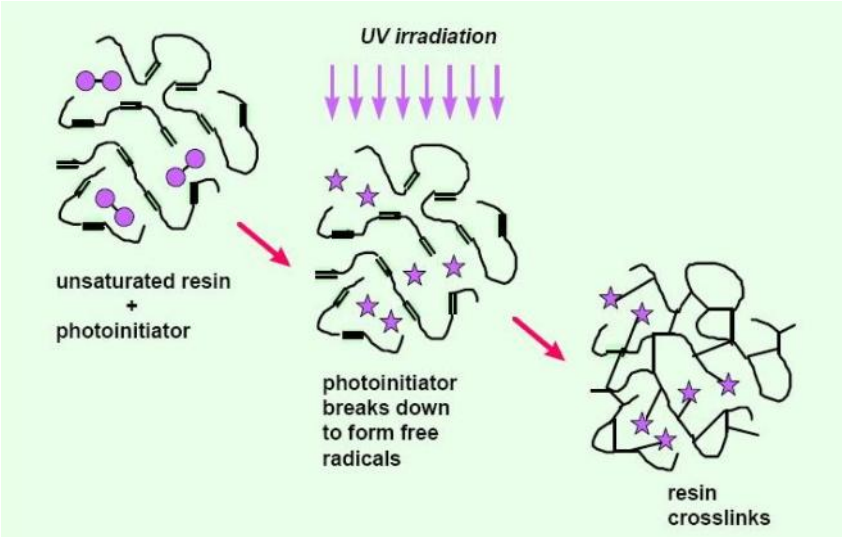
Powder Coating Overview

- **Advantages of powder coating:**
  - **Elimination of volatile organics (VOC)**
  - **Elimination of hazardous air pollutants (HAP)**
  - **Reduction/elimination of hazardous waste**
  - **Process efficiencies**
  - **Transfer efficiencies as high as 95% (w/reclaim)**

UV-Curable Powder Coatings
Overview

- **A UV-cure powder coating is generally an acrylated polymer**
- **Melts at low temperatures**
- **The powder is cured in seconds using UV light**





UV-Curable Powder Coatings
Overview

- **Decrease in thermal exposure.**
- **Large bulky parts that cannot fit into existing ovens can be coated.**
- **UV-cure powder is faster to apply and cure resulting in shorter turnaround times.**

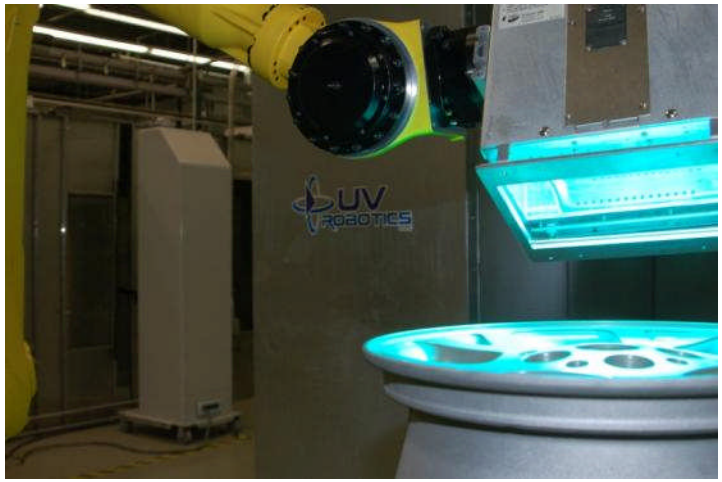
UV-Curable Powder Coatings
Overview

- **UV-cure powder requires less energy because the energy is focused to a specific part only as long as needed.**

- **UV-cure powder like all powder has high transfer efficiencies (>90%)**

Robotics as an Aid to Curing

- **Why Use Robots?**



Robotics as an Aid to Curing

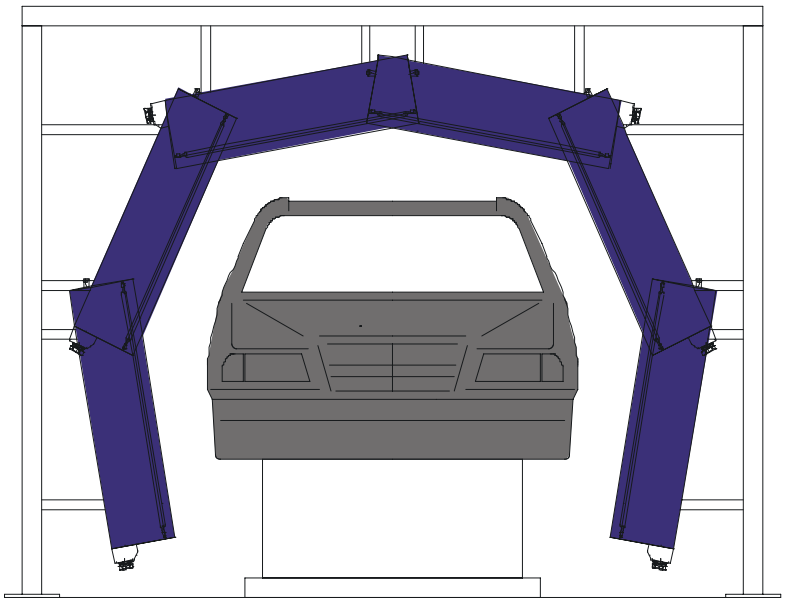
Development and use of robots for curing of UV coatings has been going on for a number of years

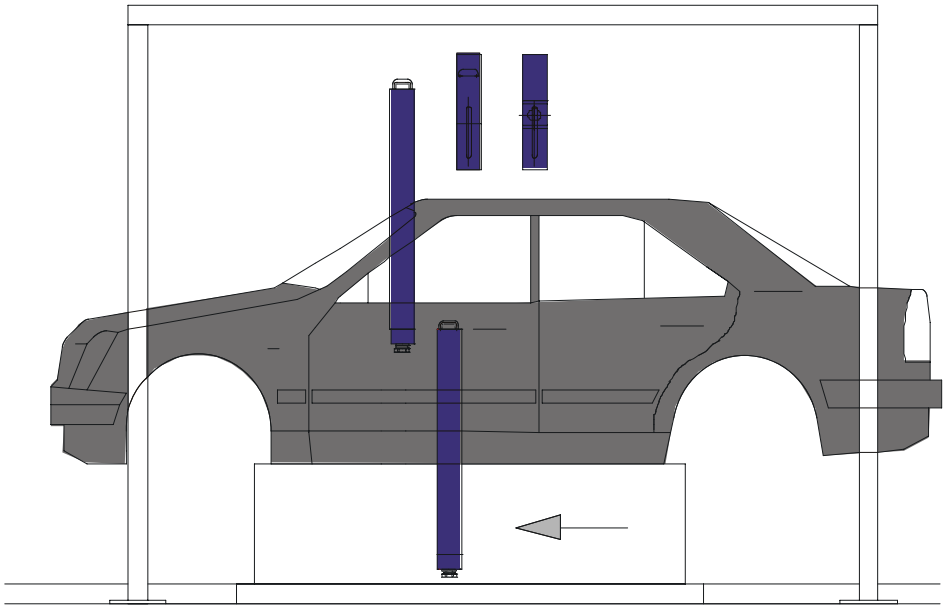
Daimler-Chrysler
Ulm, Germany

Cleveland, Ohio
Test Lab

Robotics as an Aid to Curing

Light tunnel approach using various size UV lamps to optimize cost and exposure



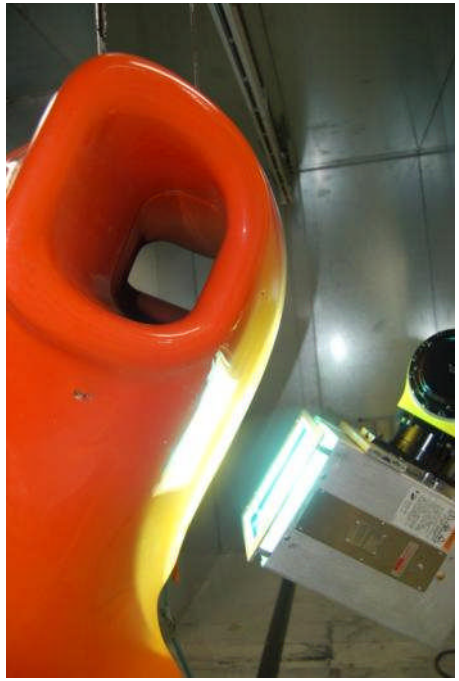


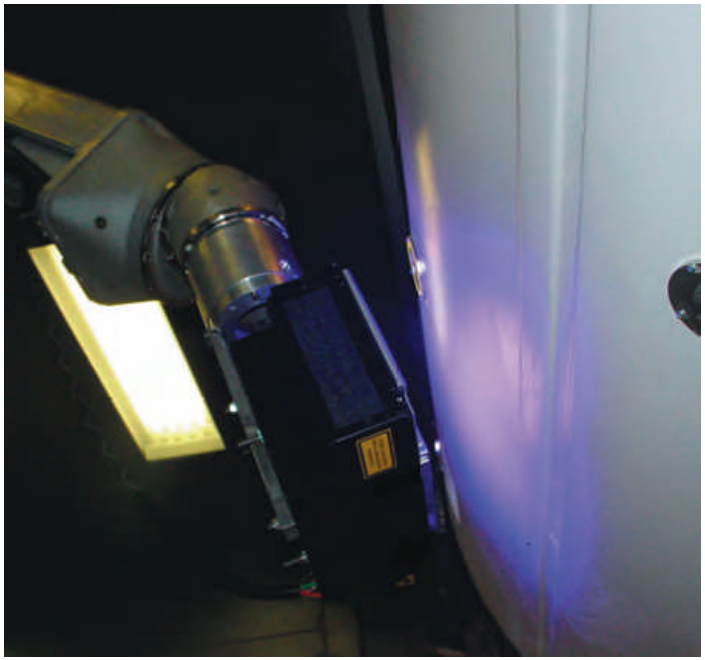
Robotics as an Aid to Curing

Drawbacks of fixed lamp approach

- **High Capital Cost**
  - **Lamps, cooling, fixtures, integration**
- **High Operating Cost**
  - **Replacement parts**
  - **Energy**
  - **Downtime**
- **Technical Adequacy**
  - **Complete cure**
  - **Proper Re-alignment**
  - **Mixed product**

Robotics as an Aid to Curing

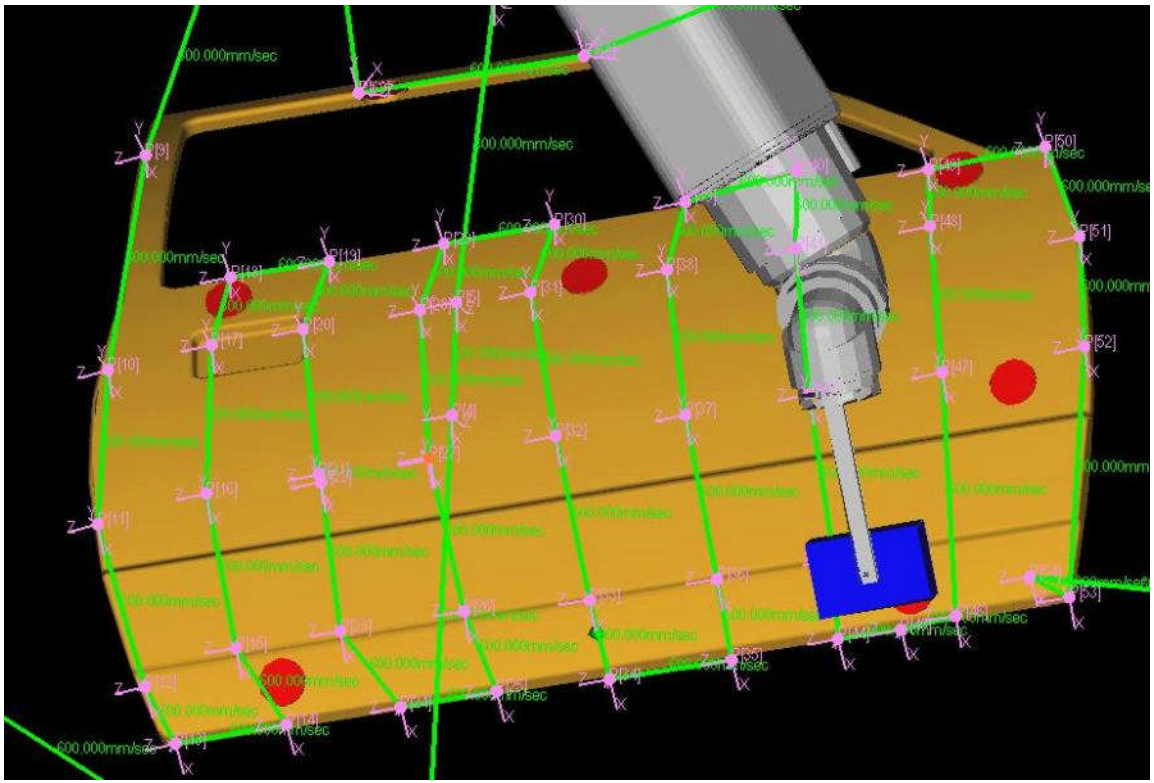




- Robots ensure repeatability
- Robots with UV sources can maintain extremely close target distances
- Robots can be re-programmed in seconds
- Robots eliminate need for many lights
- Robotic curing is well suited to large or complex parts

Robotics as an Aid to Curing

Tools have been designed to facilitate offline simulation of robotic UV curing. These tools allow for rapid path development and solve problems associated with overlap, striping, etc.



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- **The Problem:**
  - **DoD spends millions of dollars annually on solvent-based coatings**
    - **Hexavalent chrome primer use still widespread**
    - **Contains or requires volatile solvent use**
    - **Significant hazardous waste costs**
    - **Hazardous materials pose risks to human health and environment**
    - **Process times measured in hours to days**
    - **Transfer rates are less than 60%**
    - **Unused paint is costly and adds to waste burden**

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- **Objectives:**
  - **Demonstrate a VOC/HAP-free, Ultraviolet cure powder coating on DoD hardware**
  - **Demonstrate robotics for curing**

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- **Requirements of a UV-cure powder for military use:**
  - **Must perform at least as good as MIL-PRF-23377 primer**
  - **Must also perform as well as MIL-PRF-85285 topcoat.**
  - **Can be prepared in gloss, semi-gloss, and flat finishes**

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Typical Applications for UV-Cure Powder:

Lockheed C-5A "Galaxy" Landing Gear

Aircraft components

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Aircraft

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Aerospace Ground Support Equipment

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- **Powders:**
  - **Currently considering two powders**
  - **Both in gloss white, semi-gloss gray**
  - **Will undergo strict validation testing**

- **Robotics/application:**
  - **Will apply powder manually with corona gun**
  - **The robot will carry both IR and UV lamps**
  - **Evaluating two different UV light sources**
  - **Evaluating alternative application methods**

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- **Milestones**
  - **Joint Test Protocol submitted Sept 2008**
  - **Robot acquired and integration underway**
  - **Component identification completed**
  - **Ongoing UV source evaluations**
  - **Powder and substrates order Oct 2008**
  - **Validation testing starts Dec 2008**
  - **Draft Demonstration Plan June 2009**
  - **Field Service/Demonstration begins Mar 2010**
  - **Joint Test Report draft Sept 2010**
  - **Final Report Mar 2012**

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Thank you!

Points of contact for UV-curable Powder Coatings ESTCP Project WP-0801:

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